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(54) **METHOD FOR MOVING QUANTIZATION NOISE INTRODUCED IN FIXED-POINT CALCULATION OF FAST FOURIER TRANSFORMS**

VERFAHREN ZUM VERLAGERN VON BEI DER FESTKOMMABERECHNUNG VON SCHNELLEN FOURIERTRANSFORMATIONEN EINGEFÜHRTEM QUANTISIERUNGSRAUSCHEN

PROCÉDÉ DE DÉPLACEMENT DU BRUIT DE QUANTIFICATION INTRODUIT DANS LE CALCUL EN VIRGULE FIXE DE TRANSFORMÉES DE FOURIER RAPIDES

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Description

TECHNICAL FIELD

[0001] The invention relates to a method and devices within a communications network. In particular, the invention relates to process a digital signal in a wireless communication network.

BACKGROUND

[0002] In the long term evolution (LTE) of 3GPP, a new flexible air interface is currently being standardized. The LTE system will provide spectrum flexibility in the sense that carrier bandwidths varying between 1.25 MHz and 20 MHz may be handled, and both Frequency Division Duplex, FDD, and Time Division Duplex, TDD, is supported in order to be able to use both paired and unpaired spectrum. LTE is expected to be smooth evolution path for 3G standards such as WCDMA, TD-CDMA and TD-SCDMA. LTE is also expected to offer significant performance improvements as compared to current 3G standards by using, for example, various advanced antenna techniques.

[0003] In the downlink of LTE, the physical layer is based on Orthogonal Frequency Division Multiplex, OFDM. Here the information to be transmitted is coded, for example, by using turbo codes, interleaved, modulated to signal constellations of various orders, for example, QPSK, 16 QAM, 64 QAM or the like, and fed to an inverse Fast Fourier Transform (IFFT). This IFFT is a transform from a frequency domain representation of the symbols to be transmitted to a time domain representation.

[0004] In the uplink of LTE, the physical layer is based on Single Carrier- Frequency Division Multiple Access, SC-FDMA, which is also referred to as pre-coded OFDM. This means that the physical channels are built of SC-FDMA symbols. Here, the modulated symbols are transformed to the frequency domain by a Discrete Fourier Transform, DFT, of the same size as the number of modulated symbols of each SC-FDMA symbol. This is then fed to a larger IFFT with a size which depends on the bandwidth of the radio communication link.

[0005] This way, several users may be scheduled to transmit simultaneously, typically on different parts of the frequency band in a TDMA/FDMA fashion.

[0006] In the receivers of downlink and uplink the received signal is fed to a Fast Fourier Transform, FFT. This FFT enables a frequency domain extraction of each user such that the symbols for each user may be demodulated and decoded independently.

[0007] Whenever a DFT (implemented as an FFT) is used by a base station receiver on a time domain signal, said time domain signal is assumed to be periodic with period time equal to the length of the DFT. In order to ensure this for signals subject to dispersive channels, a cyclic prefix may be used. The cyclic prefix must have a length that is larger, or equal to, the delay spread of the uplink communication channel.

[0008] All these FFT:s are preferable implemented with fixed point calculations, such that the calculations can be done in cheap hardware with low power consumptions.

[0009] However, when an FFT/IFFT is calculated with fixed point calculations, a quantization noise occurs in the result. This quantization noise is larger in some regions compared to others and may deteriorate the performance of system.

[0010] Document US 2005/243938 A1 discloses an approach of FFT design as applied to multicarrier modulation systems such as OFDM. The signals are scaled so that overflow, rather than being completely avoided, occurs with low probability throughout the IFFT and FFT structures.

SUMMARY

[0011] Some embodiments are provided to reduce the impact of the quantization noise.

[0012] The invention relates to a method in an electronic communication device for processing a digital signal within a wireless communication network in order to transform the digital signal from a first domain representation to a second domain representation. The method comprises the steps of transforming the signal from the first domain to the second domain resulting in a signal of a first order of values with quantization noise in at least one area of the second domain, and performing a cyclic shift on the transformed signal to move the quantization noise in the second domain, resulting in a first shifted signal.

[0013] Thereby, the quantization noise may be moved to a less used area of the second domain.

[0014] Furthermore, an electronic communication device is provided comprising a receiving unit arranged to receive data on a carrier signal and a control unit arranged to process the carrier signal by transforming the carrier signal from a time domain to a frequency domain The control unit is further arranged to perform a first cyclic shift on the processed carrier signal resulting in a first shifted signal with quantization noise from the transforming moved in the frequency domain.

[0015] In addition, an electronic communication device is provided comprising a transmitting unit arranged to transmit data on a carrier signal and a control unit arranged to process the carrier signal before transmission by transforming the carrier signal from a frequency domain representation to a time domain representation. The control unit is further arranged to perform a cyclic shift on the processed carrier signal and thereby move quantization noise from the transforming in the time domain, resulting in a first shifted transmission signal.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] Embodiments will now be described in more detail in relation to the enclosed drawings, in which:

Figure 1 shows a schematic graph of quantization noise relative time,
Figure 2 shows a schematic graph of quantization noise relative time,
Figure 3 shows a schematic graph of quantization noise relative frequency,
Figure 4 shows a schematic graph of quantization noise relative frequency,
Figure 5 shows a schematic overview of a symbol construction,
Figure 6 shows a schematic overview of functional blocks within a transmitter,
Figure 7 shows a schematic overview of functional blocks within a receiver,
Figure 8 shows a schematic flow chart of a method in a transmitter in an OFDM system,
Figure 9 shows a schematic flow chart of a method in a receiver in an OFDM system,
Figure 10 shows a schematic overview of an electronic device,
Figure 11 shows a schematic overview of a parallel cyclic shift process in a transmitting arrangement,
Figure 12 shows a schematic overview of the signal being processed in a parallel cyclic shift process,
Figure 13 shows a schematic overview of a parallel cyclic shift process on a received signal, and
Figure 14 shows a schematic flow chart of a method in an electronic communication device for processing a digital signal.

DETAILED DESCRIPTION OF EMBODIMENTS

[0017] The present invention now will be described more fully with reference to the accompanying drawings, in which embodiments of the invention are shown. Like numbers refer to like elements throughout.

[0018] In figure 1, quantization noise as a function of time is shown after an IFFT process. The IFFT results in a region R1 with increased quantization noise Q that occurs on and in the region around time zero

[0019] A cyclic prefix CP is a part of the last samples of the OFDM symbol which is copied and repeated before the OFDM symbol shown as an arrow in figure 1. Thus, a region R2 with large quantization noise Q is transmitted twice. In many receiver algorithms, the cyclic prefix CP and the last part of the transmitted OFDM symbol are used. In some algorithms the first part of the cyclic prefix is used to make a spectrum control transaction between OFDM symbols.

[0020] In figure 2, a cyclic shift has been performed on the signal after an IFFT and the quantization noise Q is moved to a region R3 where it has small impact on the OFDM symbol. In a transmitter of an OFDM based system, the signal may be shifted after the IFFT with an amount which is significantly larger than the cyclic prefix, CP. Preferably, the signal is shifted half the length of the OFDM symbol resulting in that the region R3 with large quantization noise is placed in the middle of the OFDM symbol, and the cyclic prefix is taken from a region R2' with low quantization noise. The noisy region R3 is thereby in a region that does not deteriorate the symbol/signal.

[0021] The cyclic shift may be performed by reading the signal in a predetermined order or the signal may be stored in a memory and read from the memory in a predetermined order, for example, in the opposite order as it was written or the like, changing the order of the signal and thereby moving the quantization noise.

[0022] Figure 3 shows quantization noise as a function of frequency after an FFT process. An FFT results in a region around zero frequency that has an increased quantization noise Q. This region will be used as a carrier frequency and noise results in a deteriorated symbol.

[0023] In figure 4, the high quantization noise is moved from a carrier frequency to a sub-carrier frequency by cyclic shift after an FFT. The quantization noise Q does therefore not inflict on the signal as much.

[0024] Embodiments illustrate the cyclic shift in exemplary system, such as OFDM and SC-FDMA symbol construction which are compliant with LTE, OFDM and SC-FDMA for a future wireless communication system, FFT and IFFT in receiver of a wireless communication system and/or the like.

[0025] In figure 5, an embodiment of a system is shown wherein IFFT 10 is performed in a transmitter without frequency domain rotation. The cyclic shift 20 is performed after the IFFT 10 wherein the signal is read in a different order to move the quantization noise to a region where it does not inflict on the symbol as much, for example, a time part of the symbol not being used or less used. Optionally, the transmitter may comprise a block 30 for adding CP to the symbol to conclude a continuous signal.

[0026] In figure 6, an OFDM and SC-OFDM symbol construction for LTE is shown. In a transmitter of an OFDM based system, a rotation is performed in the time domain before the IFFT 10 and a cyclic shift 20 is performed after the IFFT 10 to restore a correct time domain signal. The quantization noise is thereby moved in time to an interval in which it interferes less with transmission and modulation.

[0027] The result of an IFFT is cyclic and may therefore be cyclically shifted at any quantity. But here the shift must be quantized by the size of the IFFT. For example, an IFFT size of 8 points limits the shift to be in parts of 1/8 of the result.

[0028] The rotation that is performed prior to the IFFT is performed with a frequency that corresponds to the selected shift position. The rotation may be performed by an element wise multiplication 6 with a rotation sequence. The rotation sequence may be pre-calculated and may be calculated by an FFT 4 where only the shift position 2 is unity in the input vector and where the other input values are zero. The shift position is mapped to the cyclic shift. The rotation may then be normalized 5 such that it only modifies the phase and not the amplitude in the element wise multiplication. Then the frequency data shall be multiplied with the rotation before the IFFT of frequency data.

[0029] Preferably, the shift position equals half the length of the OFDM symbol, see figure 2, resulting in that the region R3 with large quantization noise is placed in the middle of the OFDM symbol, and the cyclic prefix is taken from a region R2' with low quantization noise. The noisy region R3 is thereby in a region that does not deteriorate the symbol/signal.

[0030] To use an element wise multiplication sequence 6 may also with advantage be included in the symbol modulation.

[0031] The IFFT 10 is then performed on the signal resulting in representation of the symbol in the time domain. After the IFFT 10, the time domain data is processed in a cyclic shift 20 according to the selected shift position 2 so that the shift position 2 corresponds to start and end of the signal and the quantization noise is concentrated to one period in time.

[0032] OFDM and SC-FDMA symbols may be constructed which are compliant with LTE, with the use of this approach of element wise multiplication with a rotation sequence before IFFT and cyclic shift after IFFT.

[0033] If the element wise multiplication with a rotation sequence is excluded before the IFFT, but the cyclic shift after the IFFT is performed, as shown in figure 5, OFDM (or SC-FDMA) symbols which is not compliant with LTE, will be constructed. One reason for omitting this rotation sequence is to reduce computational complexity in the transmitter.

[0034] This way of calculating OFDM and SC-FDMA symbols results in that transmitted symbols will contain less quantization noise.

[0035] In figure 7, a system is shown wherein FFT and IFFT are performed in receiver algorithms. Embodiments may also be used on the receiver side where the used frequency interval of the transmission is centered on the carrier frequency. Here an FFT 110 is used to transform the information to the frequency domain. With an ordinary FFT, the quantization noise will be largest in an interval around the carrier frequency. But by using an element wise multiplication 106 with a rotation sequence before FFT 110 and cyclic shift 120 after FFT the noise may be shifted out of the used frequency interval, see figure 4 to a sub-carrier frequency not or less used.

[0036] The rotation sequence is similarly calculated as in the transmitter case. That is, the rotation that is performed prior to the FFT 110 is performed with a time slot that corresponds to a selected shift position 102. The rotation sequence may be pre-calculated and may be calculated by an IFFT 104 where only the shift position 102 is unity in the input frequency and where the other input values are zero. The shift position 102 is mapped to the cyclic shift 120. The rotation may then be normalized 105 such that it only modifies the phase and not the amplitude in the element wise multiplication. Then the time domain data shall be multiplied with the rotation before the FFT of time domain data.

[0037] The FFT transform the data in the time domain to data in the frequency domain and a cyclic shift is performed on the data to move the noise from the quantization of the data to a frequency not/less used.

[0038] Embodiments result in less fixed point quantization noise in transmitted OFDM and SC-FDMA signals. Embodiments may be included in future OFDM based wireless communication standards, since it provides improved system performance with reduced hardware cost in both mobiles and terminals. Embodiments may also be implemented in receiving arrangements to improve performance of receiver algorithms.

[0039] Figure 8 shows a schematic flow chart of a method in an OFDM transmitter.

[0040] In optional step 80, a first step of a rotation in a time domain is performed. The step is to input a shift position mapped against the cyclic shift as a vector signal.

[0041] In optional step 82, an FFT on the shift position signal is performed resulting in a frequency signal corresponding to the time domain signal, a rotation sequence.

[0042] In optional step 84, an element wise multiplication is performed mixing the rotated signal and an input signal S by multiplying the signal S with the rotation sequence from the FFT.

[0043] In step 86, an IFFT is performed on the multiplied signal and a cyclic result is obtained in the frequency domain.

[0044] In step 88, a cyclic shift corresponding to the shift position is performed on the signal from the IFFT wherein data is shifted relative the frequency data resulting in a de-rotated signal but with a moved quantization noise.

[0045] In optional step 90, a region for cyclic prefix is copied in the end of the OFDM symbol having a low quantization noise.

[0046] In figure 9, a schematic flow chart in a receiver of an OFDM communication network is shown.

[0047] In optional step 92, a shift position is added as a vector signal in order to shift and rotate the signal in accordance with the later cyclic shift. The shift position is fed to the IFFT.

[0048] In optional step 94, a transformation is performed from a frequency domain to the time domain using an IFFT. The resulting signal may be normalized.

[0049] In optional step 96, an element wise multiplication is performed mixing the rotated signal and an input signal S by multiplying the signal S with the rotation sequence from the IFFT.

[0050] In step 98, an FFT is performed on the multiplied signal and a cyclic result is obtained in the time domain.

[0051] In step 100, a cyclic shift is performed on the signal from the FFT wherein data is shifted relative the time domain data resulting in a de rotated signal but with a moved quantization noise.

[0052] In figure 10, a schematic overview of an electronic communication device 200 is shown. The electronic communication device 200 comprises a control unit 201 CPU connected to a memory 207 for storing data and reading data from. The electronic communication device 200 further comprises a receiving unit 203 RX arranged to receive a signal R from, for example, a wireless communication device or the like, and a transmitting unit 205 TX arranged to transmit a signal T to, for example, a wireless communication device, a base station and/or the like.

[0053] The electronic communication device 200 may be a wireless communication device, for example, a PDA, a mobile telephone or the like, a base station, an evolved NodeB, a combined RBS and RNC and/or the like.

[0054] The control unit 201 may be arranged to perform signal processing before transmitting the data comprising CRC generation, turbo coding, scrambling, modulation, mapping, IFFT and cyclic prefix insertion, in for example, downlink DL in LTE. In the uplink UL in LTE, the control unit 201 may be arranged to perform signal processing before transmitting the data comprising CRC generation, turbo coding, scrambling, modulation, DFT, mapping, IFFT and cyclic prefix insertion.

[0055] In order to transmit less fixed point quantization noise in OFDM and SC-FDMA signals the control unit 201 may be arranged to perform a cyclic shift after the IFFT. The data from the IFFT may be stored in the memory 207 and the cyclic shift may be performed by reading the stored data in a different order/ different initial value than how it was stored. Furthermore, in embodiments the control unit 201 is arranged to perform an element wise multiplication on the data before the IFFT. The element wise multiplication means that the input signal to the IFFT is multiplied with a rotation sequence. The rotation sequence may be pre-calculated or the like by, for example, inputting a signal position vector corresponding to the cyclic shift into an FFT resulting in a rotation sequence, this, as well, may be performed by the control unit 201.

[0056] It should also be noted that the cyclic shift may be performed on the FFT in order to move regions of high quantization noise. Consequently, the element wise multiplication may be performed on the modulated signal.

[0057] In embodiments the control unit 201 may be arranged to perform signal processing on a received signal by performing the following steps, removing CP, performing FFT, extracting users from the signal, demodulating the signal, and decoding the signal. In order to prevent quantization noise from the Fourier transformation the control unit 201 may be arranged to perform a cyclic shift on the received signal after the FFT.

[0058] The data from the FFT may be stored in the memory 207 and the cyclic shift may be performed by reading the stored data in a different order/ different initial value than how it was stored. Furthermore, in some embodiments the control unit 201 is arranged to perform an element wise multiplication on the data before the FFT. The element wise multiplication means that the input signal to the FFT is multiplied with a rotation sequence. The rotation sequence may be pre-calculated or the like by, for example, inputting a signal position vector corresponding to the cyclic shift into an IFFT resulting in a rotation sequence, this, as well, may be performed by the control unit 201.

[0059] The electronic communication device 200 may hence include means to move the quantization noise in received signal, means to move the quantization noise in a transmission signal or a combination thereof moving the quantization noise in both the received signal as well as the transmitted signal.

[0060] A parallel process may be implemented into the transmitting arrangement and/or the receiving arrangement.

[0061] In figure 11, an embodiment of a transmitting arrangement with a parallel process is shown. In a first cyclic shift arrangement CS1, a first position shift 2 is implemented into a first FFT 4, which in its turn is multiplied with an input signal S in a first element wise multiplier 6. The rotated signal is transformed in an IFFT 10 and the quantization noise is moved in a first cyclic shift process 20, resulting in a first shifted signal.

[0062] In a parallel second cyclic shift arrangement CS2, a second shift position 2' is implemented, this one being different than the first shift position 2, into a second FFT 4', which in its turn is multiplied with the input signal S in a second element wise multiplier 6'. The rotated signal is transformed in a second IFFT 10' and the quantization noise is moved in a second cyclic shift process 20', resulting in a second shifted signal.

[0063] The shifted signal from the first CS1 may then be combined in a combiner 25, wherein the noisy region/s in the first shifted signal is replaced with the similar regions of the second shifted signal from the second CS2. This results in a combined shifted signal where the regions of high quantization noise is eliminated/reduced.

[0064] In figure 12, a schematic overview of a signal S that is processed in a parallel cyclic shift process is shown. The quantization noise regions in the signal after an IFFT is moved in the first CS1 and the second CS2, resulting in two signals with different regions of high quantization noise. The noisy region R3 of the first signal is then swapped/combined with the same region in the second signal in a combiner 25, but with a low quantization noise, resulting in a signal with low quantization noise all over the domain. The process will be similar in a receiving arrangement with a result of a low quantization noise over the frequency domain.

[0065] In figure 13, a schematic overview of an embodiment for processing a received signal with a parallel process is shown.

[0066] In a first receiving cyclic shift arrangement RCS1, a first position shift 102 is implemented into a first IFFT 104, which in its turn is multiplied with an input signal S in a first element wise multiplier 106. The rotated signal is transformed in an FFT 110 and the quantization noise is moved in a first cyclic shift process 120, resulting in a first shifted signal.

[0067] In a parallel second receiving cyclic shift arrangement RCS2, a second shift position 102' is implemented, this one being different than the first shift position 102, into a second IFFT 104', which in its turn is multiplied with the input signal S in a second element wise multiplier 106'. The rotated signal is transformed in a second FFT 110' and the quantization noise is moved in a second cyclic shift process 120', resulting in a second shifted signal.

[0068] The shifted signal from the first RCS1 may then be combined in a combiner 125, wherein the noisy region/s in the first shifted signal is replaced with the similar regions of the second shifted signal from the second RCS2. This results in a combined shifted signal where the regions of high quantization noise is eliminated/reduced.

[0069] Referring to figure 14, embodiments disclose a method in an electronic communication device for processing a digital signal within a wireless communication network in order to transform the digital signal from a first domain representation to a second domain representation.

[0070] In optional step 306, the digital signal is multiplied with a rotation sequence in the first domain.

[0071] The rotation sequence may be calculated from an input of a selected shift position and a transformation from the second domain to the first domain.

[0072] The transformation in the calculation of the rotation sequence may comprise an FFT or an IFFT.

[0073] In step 308, the signal is transformed from the first domain to the second domain resulting in a signal of a first order of values with quantization noise in at least one area of the second domain.

[0074] The transforming step may comprise an Inverse Fast Fourier Transformation, IFFT, wherein the first domain is a frequency domain and the second domain is a time domain

[0075] Furthermore, the transforming step may comprise a Fast Fourier Transformation, FFT, wherein the first domain is a time domain and the second domain is a frequency domain.

[0076] In step 310, a cyclic shift is performed on the transformed signal to move the quantization noise in the second domain, resulting in a first shifted signal.

[0077] The cyclic shift may be performed by reading the transformed signal values in a second order being different than the first order.

[0078] In some embodiments, the signal is an OFDM signal and the signal may be shifted half the length of an OFDM symbol.

[0079] In optional step 312, the first shifted signal from a first cyclic shift process is combined with a second shifted signal from a second cyclic shift process by swapping a region in the second domain of the first shifted signal with a corresponding region in the second domain of the second shifted signal.

[0080] The second cyclic shift may be performed with a different rotation sequence, resulting in that the second shifted signal is being different than the first shifted signal.

[0081] Referring back to figure 9, in order to perform the method an electronic communication device 200 is provided. The electronic communication device comprises a receiving unit 203 arranged to receive data on a carrier signal and a control unit 201 arranged to process the carrier signal by transforming the carrier signal from a time domain to a frequency domain. The control unit 201 is further arranged to perform a first cyclic shift on the processed carrier signal resulting in a first shifted signal with quantization noise from the transforming moved in the frequency domain.

[0082] The control unit 201 may be arranged to multiply the carrier signal with a rotation sequence in the time domain. Furthermore, the control unit 201 may be arranged to calculate the rotation sequence by performing a Inverse Fast Fourier transformation from the frequency domain to the time domain with an input of a selected position shift.

[0083] The control unit 201 may further be arranged to perform a Fast Fourier Transformation to transform the signal from the time domain to the frequency domain.

[0084] In some embodiments, the control unit 201 may be arranged to perform a parallel signal process of the carrier signal by transforming the carrier signal from a time domain to a frequency domain and to perform a second cyclic shift on the processed carrier signal being different than the first cyclic shift, resulting in a second shifted signal and the control unit 201 is further arranged to combine the first shifted signal with the second shifted signal to swap a noisy region in the first shifted signal with a corresponding region in the second shifted signal.

[0085] The electronic communication device may further comprise a transmitting unit 205 arranged to transmit data on a second carrier signal and the control unit 201 is arranged to process the second carrier signal before transmission by transforming the second carrier signal from a frequency domain to a time domain and the control unit 201 is further arranged to perform a transmission cyclic shift on the processed second carrier signal and thereby move quantization noise from the transforming in the time domain, resulting in a first shifted transmission signal.

[0086] The control unit 201 may in some embodiments be arranged to multiply the second carrier signal with a rotation sequence in the frequency domain.

[0087] The control unit 201 may be arranged to calculate the rotation sequence by performing a Fast Fourier Transformation from the time domain to the frequency domain with an input of a selected shift position.

[0088] The control unit 201 may be arranged to perform an Inverse Fast Fourier Transformation to transform the signal from the frequency domain to the time domain.

[0089] The control unit may perform the steps as a application or a plurality of applications are executed on the control unit. The application/s may be stored on a local/external memory.

[0090] In some embodiments, an electronic communication device 200 is provided, wherein the control unit 201 is arranged to perform a parallel signal process on the second carrier signal by transforming the second carrier signal from a time domain to a frequency domain. The control unit 201 is further arranged to perform a second transmission cyclic shift of the processed second carrier signal being different than the first transmission cyclic shift, resulting in a second shifted transmission signal and to combine the first shifted transmission signal with the second shifted transmission signal to swap a noisy region in the first shifted transmission signal with a corresponding region in the second shifted transmission signal.

[0091] Furthermore, in order to perform methods on a transmitting signal an electronic communication device 200 is provided comprising a transmitting unit 205 arranged to transmit data on a carrier signal and a control unit 201 arranged to process the carrier signal before transmission by transforming the carrier signal from a frequency domain representation to a time domain representation. The control unit 201 is further arranged to perform a cyclic shift on the processed carrier signal and thereby move quantization noise from the transforming in the time domain, resulting in a first shifted transmission signal.

[0092] The cyclic shift may be performed by reading the transformed signal values in a second order being different than the first order.

The control unit 201 may be arranged to multiply the digital signal with a rotation sequence in the frequency domain.

[0093] The control unit 201 may further be arranged to calculate the rotation sequence by performing a Fast Fourier Transformation from the time domain to the frequency domain with an input of a selected shift position.

[0094] The control unit 201 may be arranged to perform an Inverse Fast Fourier Transformation to transform the carrier signal from the frequency domain to the time domain.

[0095] The control unit 201 may, in some embodiments, be arranged to perform a parallel signal process of the carrier signal by transforming the carrier signal from a time domain to a frequency domain and to perform a second cyclic shift on the processed carrier signal being different than the first cyclic shift, resulting in a second shifted transmission signal and the control unit 201 is further arranged to combine the first shifted transmission signal with the second shifted transmission signal to swap a noisy region in the first shifted signal with a corresponding region in the second shifted transmission signal.

[0096] The electronic communication device 200 may represent a mobile communication terminal and/or a radio base station.

[0097] In the drawings and specification, there have been disclosed exemplary embodiments of the invention. However, many variations and modifications can be made to these embodiments without substantially departing from the principles of the present invention. Accordingly, although specific terms are employed, they are used in a generic and descriptive sense only and not for purposes of limitation, the scope of the invention being defined by the following claims.

Claims

1. A method in an electronic communication device for processing a digital signal within a wireless communication network in order to transform the digital signal from a first domain representation to a second domain representation, comprising the steps of:

    - transforming (86, 98, 308) the signal from the first domain to the second domain resulting in a signal of a first order of values with quantization noise in at least one area of the second domain, and
    - performing (88, 100, 310) a cyclic shift on the transformed signal to move the quantization noise in the second domain, resulting in a first shifted signal.

2. A method according to claim 1, wherein the cyclic shift is performed by reading the transformed signal values in a second order being different than the first order.

3. A method according to any of claims 1-2, wherein the method further comprises a step multiplying (306) the digital signal with a rotation sequence in the first domain.

4. A method according to claim 3, wherein the rotation sequence is calculated from a input of a selected shift position and a transformation from the second domain to the first domain.

5. A method according to claim 4, wherein the transformation in the calculation of the rotation sequence comprises an FFT.

6. A method according to claim 4, wherein the transformation in the calculation of the rotation sequence comprises an IFFT.

7. A method according to any of claims 1-6, wherein the transforming step comprises an Inverse Fast Fourier Transformation, IFFT, and the first domain is a frequency domain and the second domain is a time domain.

8. A method according to any of claims 1-6, wherein the transforming step comprises a Fast Fourier Transformation, FFT, and the first domain is a time domain and the second domain is a frequency do-

main.

9. A method according to any of claims 1-8, wherein the signal is an OFDM signal and the signal is shifted half the length of an OFDM symbol.

10. A method according to any of claims 1-9, wherein the method further comprises a step of combining (312) the first shifted signal from a first cyclic shift process with a second shifted signal from a second cyclic shift process by swapping a region in the second domain of the first shifted signal with a corresponding region in the second domain of the second shifted signal.

11. A method according to claim 10, wherein the second cyclic shift is performed with a different rotation sequence, resulting in that the second shifted signal is different than the first shifted signal.

12. An electronic communication device (200) comprising a receiving unit (203) arranged to receive data on a carrier signal and a control unit (201) arranged to process the carrier signal by transforming the carrier signal from a time domain to a frequency domain **characterised in that** the control unit (201) is further arranged to perform a first cyclic shift on the processed carrier signal resulting in a first shifted signal with quantization noise from the transforming moved in the frequency domain.

13. An electronic communication device (200) comprising a transmitting unit (205) arranged to transmit data on a carrier signal and a control unit (201) arranged to process the carrier signal before transmission by transforming the carrier signal from a frequency domain representation to a time domain representation **characterised in that** the control unit (201) is further arranged to perform a cyclic shift on the processed carrier signal and thereby move quantization noise from the transforming in the time domain, resulting in a first shifted transmission signal.

14. An electronic communication device according to any of the claims 12-13, wherein the electronic communication device (200) represents a mobile communication terminal.

15. An electronic communication device according to any of the claims 12-13, wherein the electronic communication device (200) represents a radio base station.

Patentansprüche

1. Verfahren, in einer elektronischen Kommunikationsvorrichtung, zum Verarbeiten eines digitalen Signals innerhalb eines drahtlosen Kommunikationsnetzes, um das digitale Signal von einer ersten Bereichsdarstellung in eine zweite Bereichsdarstellung zu transformieren, umfassend die folgenden Schritte:

   - Transformieren (86, 98, 308) des Signals von dem ersten Bereich in den zweiten Bereich, was zu einem Signal einer ersten Reihenfolge von Werten mit Quantisierungsrauschen in zumindest einem Gebiet des zweiten Bereichs führt, und
   - Durchführen (88, 100, 310) einer zyklischen Verschiebung auf dem transformierten Signal, um das Quantifizierungsrauschen in den zweiten Bereich zu verlagern, was zu einem ersten verschobenen Signal führt.

2. Verfahren nach Anspruch 1, wobei die zyklische Verschiebung durchgeführt wird, indem die transformierten Signalwerte in einer zweiten Reihenfolge gelesen werden, die sich von der ersten Reihenfolge unterscheidet.

3. Verfahren nach einem der Ansprüche 1-2, wobei das Verfahren ferner einen Schritt des Multiplizierens (306) des digitalen Signals mit einer Rotationssequenz in dem ersten Bereich umfasst.

4. Verfahren nach Anspruch 3, wobei die Rotationssequenz aus einer Eingabe einer ausgewählten Verschiebungsposition und einer Transformation von dem zweiten Bereich zu dem ersten Bereich berechnet wird.

5. Verfahren nach Anspruch 4, wobei die Transformation bei der Berechnung der Rotationssequenz eine FFT umfasst.

6. Verfahren nach Anspruch 4, wobei die Transformation bei der Berechnung der Rotationssequenz eine IFFT umfasst.

7. Verfahren nach einem der Ansprüche 1-6, wobei der Transformationsschritt eine umgekehrte schnelle Fouriertransformation, IFFT, umfasst, und der erste Bereich ein Frequenzbereich ist und der zweite Bereich ein Zeitbereich ist.

8. Verfahren nach einem der Ansprüche 1-6, wobei der Transformationsschritt eine schnelle Fouriertransformation, FFT, umfasst, und der erste Bereich ein Zeitbereich ist und der zweite Bereich ein Frequenzbereich ist.

9. Verfahren nach einem der Ansprüche 1-8, wobei das Signal ein OFDM-Signal ist und das Signal um die Hälfte der Länge eines OFDM-Symbols verschoben ist.

10. Verfahren nach einem der Ansprüche 1-9, wobei das Verfahren ferner einen Schritt des Kombinierens (312) des ersten verschobenen Signals von einem ersten zyklischen Verschiebungsprozess mit einem zweiten verschobenen Signal von einem zweiten zyklischen Verschiebungsprozess umfasst, indem eine Region in dem zweiten Bereich des ersten verschobenen Signals mit einer entsprechenden Region in dem zweiten Bereich des zweiten verschobenen Signals ausgetauscht wird.

11. Verfahren nach Anspruch 10, wobei die zweite zyklische Verschiebung mit einer unterschiedlichen Rotationssequenz durchgeführt wird, was dazu führt, dass sich das zweite verschobene Signal von dem ersten verschobenen Signal unterscheidet.

12. Elektronische Kommunikationsvorrichtung (200), umfassend eine Empfangseinheit (203), die angeordnet ist, um Daten auf einem Trägersignal zu empfangen, und eine Steuereinheit (201), die angeordnet ist, um das Trägersignal zu verarbeiten, indem das Trägersignal von einem Zeitbereich in einen Frequenzbereich transformiert wird, **dadurch gekennzeichnet, dass** die Steuereinheit (201) ferner angeordnet ist, um eine erste zyklische Verschiebung auf dem verarbeiteten Trägersignal durchzuführen, was zu einem ersten verschobenen Signal mit Quantifizierungsrauschen von der in den Frequenzbereich verlagerten Transformation führt.

13. Elektronische Kommunikationsvorrichtung (200), umfassend eine Übertragungseinheit (205), die angeordnet ist, um Daten auf einem Trägersignal zu übertragen, und eine Steuereinheit (201), die angeordnet ist, um das Trägersignal vor der Übertragung zu verarbeiten, indem das Trägersignal von einer Frequenzbereichsdarstellung in eine Zeitbereichsdarstellung transformiert wird, **dadurch gekennzeichnet, dass** die Steuereinheit (201) ferner angeordnet ist, um eine zyklische Verschiebung auf dem verarbeiteten Trägersignal durchzuführen und dadurch das Quantifizierungsrauschen von der Transformation in den Zeitbereich zu verlagern, was zu einem ersten verschobenen Übertragungssignal führt.

14. Elektronische Kommunikationsvorrichtung nach einem der Ansprüche 12-13, wobei die elektronische Kommunikationsvorrichtung (200) ein mobiles Kommunikationsendgerät darstellt.

15. Elektronische Kommunikationsvorrichtung nach einem der Ansprüche 12-13, wobei die elektronische Kommunikationsvorrichtung (200) eine Funkbasisstation darstellt.

Revendications

1. Procédé dans un dispositif de communication électronique pour traiter un signal numérique à l'intérieur d'un réseau de communication sans fil afin de transformer le signal numérique d'une première représentation de domaine à une seconde représentation de domaine, comprenant les étapes consistant à :

- transformer (86, 98, 308) un signal du premier domaine au second domaine ayant pour résultat un signal d'un premier ordre de valeurs avec un bruit de quantification dans au moins une zone du second domaine, et
- effectuer (88, 100, 310) un décalage cyclique sur le signal transformé pour déplacer le bruit de quantification dans le second domaine, ayant pour résultat un premier signal décalé.

2. Procédé selon la revendication 1, dans lequel le décalage cyclique est effectué en lisant les valeurs du signal transformé dans un second ordre qui est différent du premier ordre

3. Procédé selon l'une quelconque des revendications 1 à 2, dans lequel le procédé comprend en outre une étape multipliant (306) le signal numérique avec une séquence de rotation dans le premier domaine.

4. Procédé selon la revendication 3, dans lequel la séquence de rotation est calculée à partir d'une entrée d'une position de décalage sélectionnée et d'une transformation du second domaine au premier domaine.

5. Procédé selon la revendication 4, dans lequel la transformation dans le calcul de la séquence de rotation comprend une FFT.

6. Procédé selon la revendication 4, dans lequel la transformation dans le calcul de la séquence de rotation comprend une IFFT.

7. Procédé selon l'une quelconque des revendications 1 à 6, dans lequel l'étape de transformation comprend une Transformation de Fourier Rapide Inverse, IFFT, et le premier domaine est un domaine fréquentiel et le second domaine est un domaine temporel.

8. Procédé selon l'une quelconque des revendications 1 à 6, dans lequel l'étape de transformation comprend une Transformation de Fourier Rapide, FFT, et le premier domaine est un domaine temporel et le second domaine est un domaine fréquentiel.

9. Procédé selon l'une quelconque des revendications 1 à 8, dans lequel le signal est un signal OFDM et le signal est décalé de la moitié de la longueur d'un symbole OFDM.

10. Procédé selon l'une quelconque des revendications 1 à 9, dans lequel le procédé comprend en outre une étape consistant à combiner (312) le premier signal décalé d'un premier processus de décalage cyclique avec un second signal décalé d'un second processus de décalage cyclique en échangeant une région dans le second domaine du premier signal décalé avec une région correspondante dans le second domaine du second signal décalé.

11. Procédé selon la revendication 10, dans lequel le second décalage cyclique est effectué avec une séquence de rotation différente, ayant pour résultat le fait que le second signal décalé est différent du premier signal décalé.

12. Dispositif de communication électronique (200) comprenant une unité de réception (203) agencée pour recevoir des données sur un signal porteur et une unité de commande (201) agencée pour traiter le signal porteur en transformant le signal porteur d'un domaine temporel à un domaine fréquentiel, **caractérisé en ce que** l'unité de commande (201) est en outre agencée pour effectuer un premier décalage cyclique sur le signal porteur traité ayant pour résultat un premier signal décalé avec un bruit de quantification provenant de la transformation déplacé dans le domaine fréquentiel.

13. Dispositif de communication électronique (200) comprenant une unité de transmission (205) agencée pour transmettre des données sur un signal porteur et une unité de commande (201) agencée pour traiter le signal porteur avant la transmission en transformant le signal porteur d'une représentation de domaine fréquentiel à une représentation de domaine temporel, **caractérisé en ce que** l'unité de commande (201) est en outre agencée pour effectuer un décalage cyclique sur le signal porteur traité et déplacer ainsi un bruit de quantification provenant de la transformation dans le domaine temporel, ayant pour résultat un premier signal de transmission décalé.

14. Dispositif de communication électronique selon l'une quelconque des revendications 12 à 13, dans lequel le dispositif de communication électronique (200) représente un terminal de communication mobile.

15. Dispositif de communication électronique selon l'une quelconque des revendications 12 à 13, dans lequel le dispositif de communication électronique (200) représente une station de base radio.

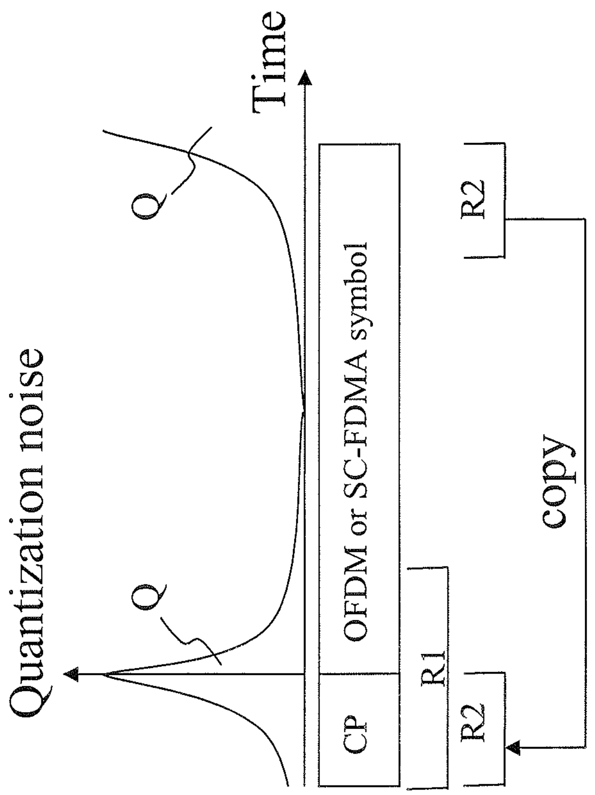

FIGURE 1

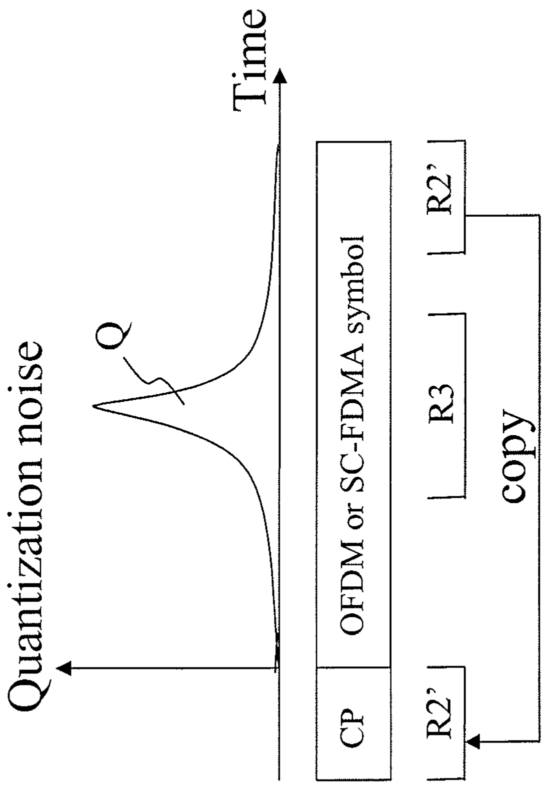

FIGURE 2

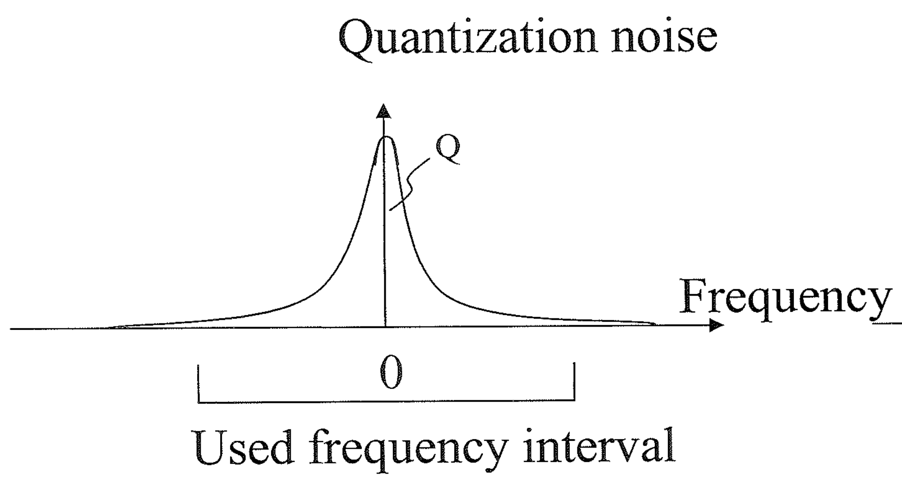

FIGURE 3

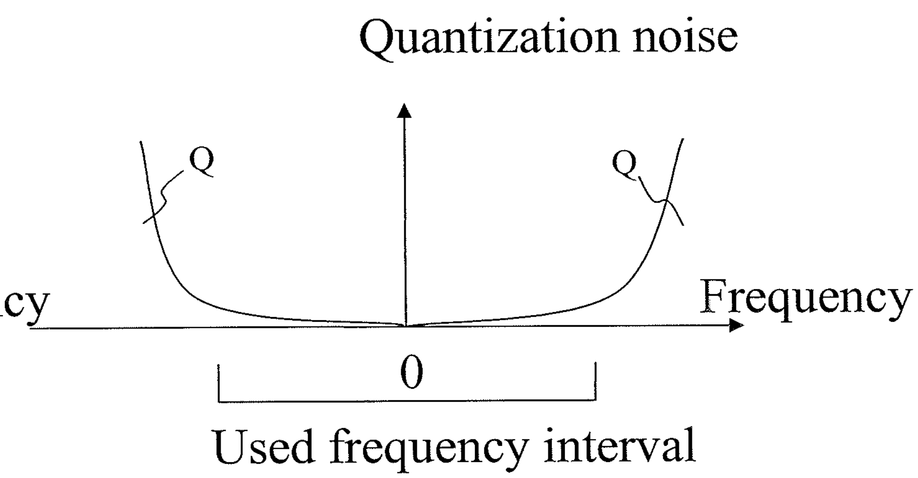

FIGURE 4

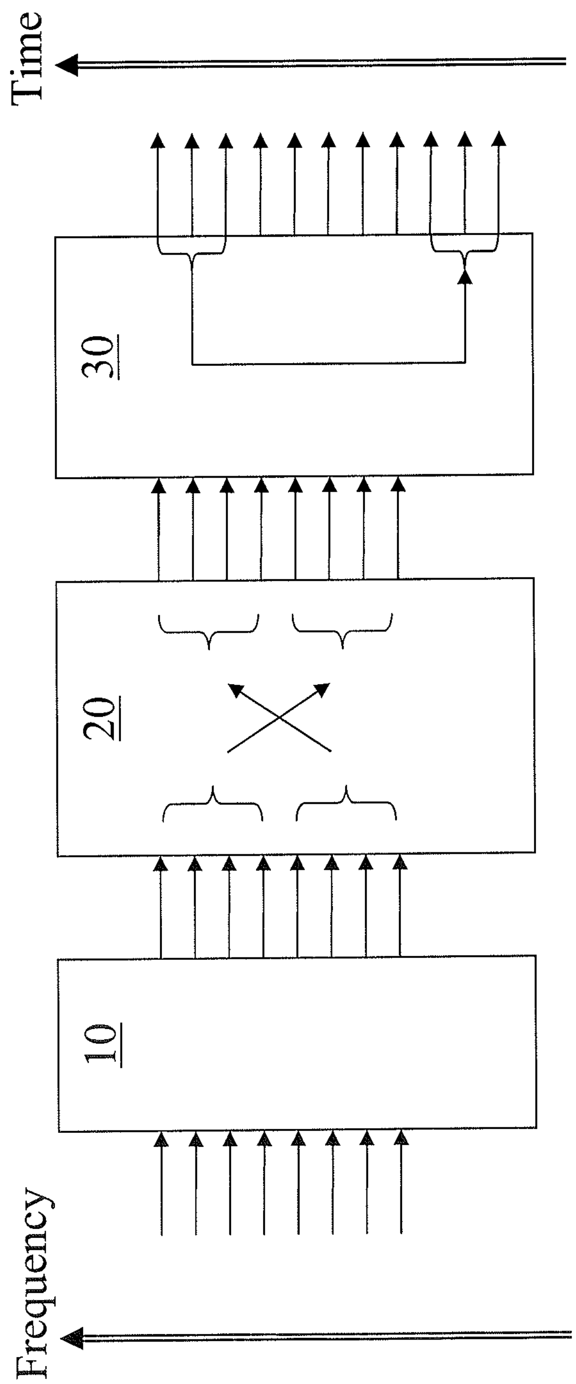

FIGURE 5

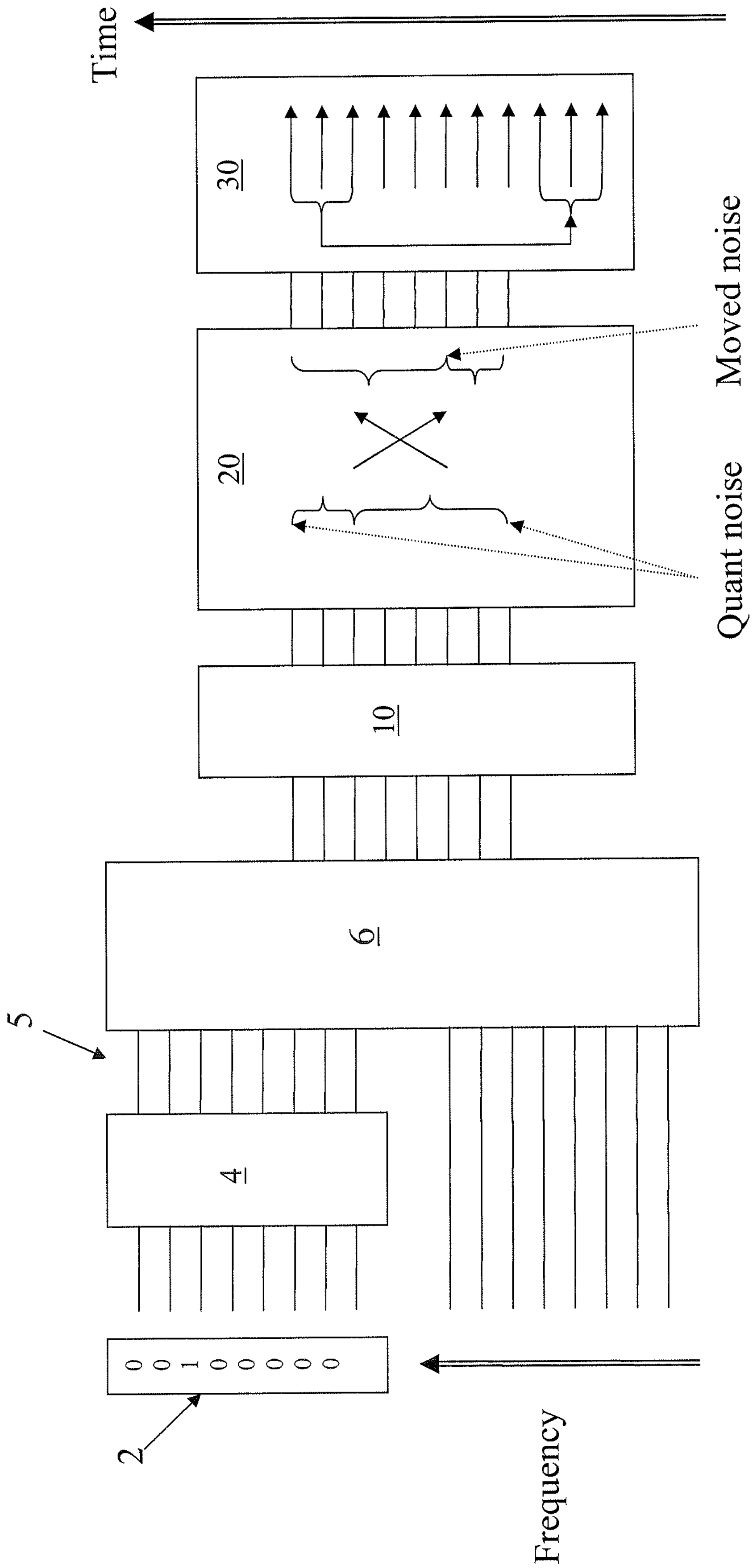
Time
30
20
Moved noise
Quant noise
10
6
5
4
0 0 1 0 0 0 0
2
Frequency

FIGURE 6

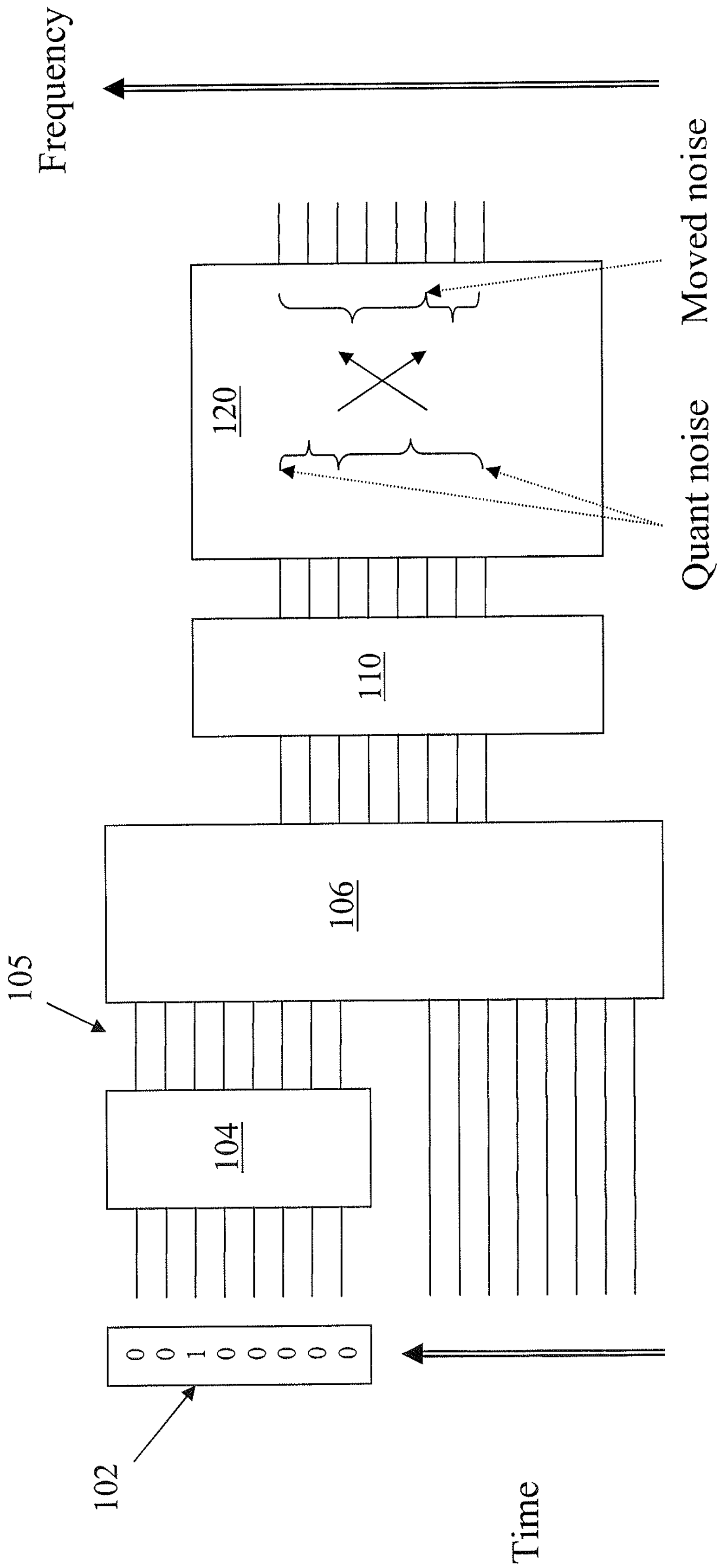
Frequency
Moved noise
Quant noise
120
110
106
105
104
0 0 1 0 0 0 0
102
Time

FIGURE 7

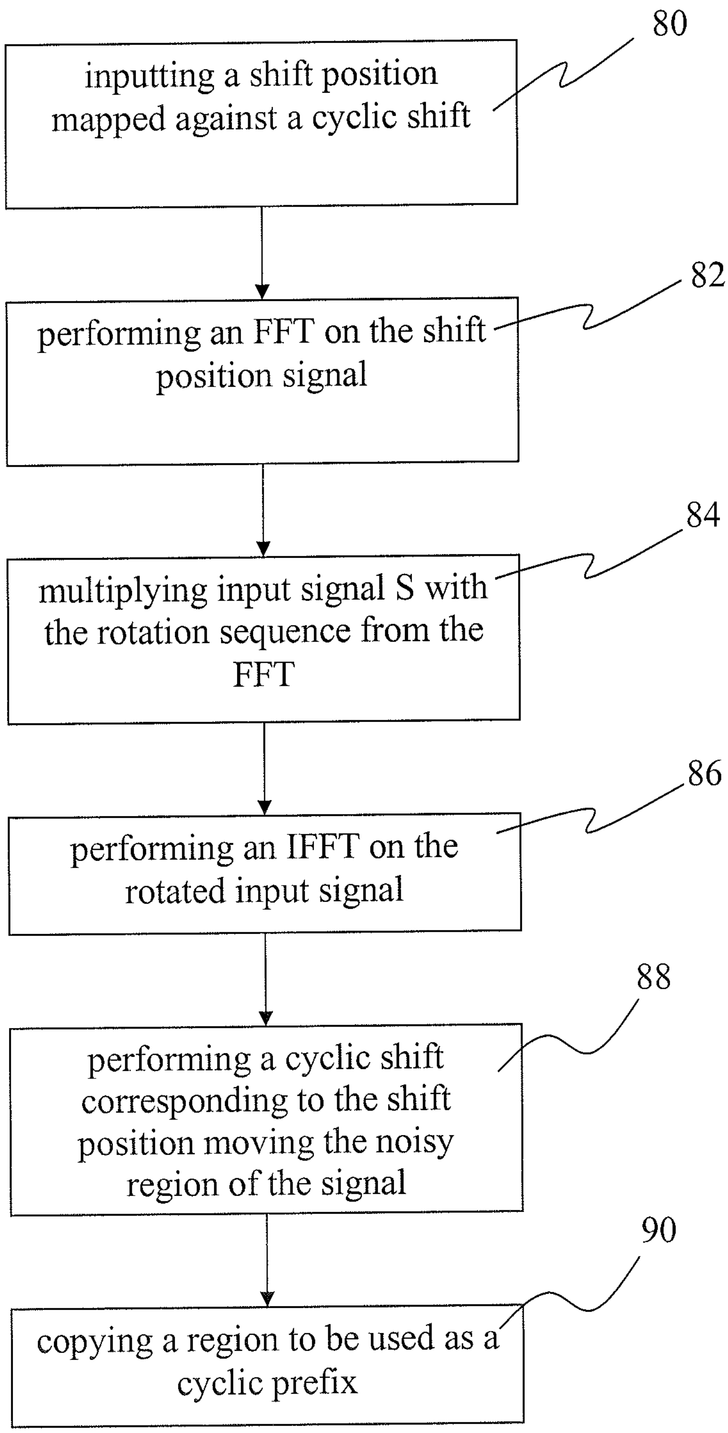
80
inputting a shift position mapped against a cyclic shift
82
performing an FFT on the shift position signal
84
multiplying input signal S with the rotation sequence from the FFT
86
performing an IFFT on the rotated input signal
88
performing a cyclic shift corresponding to the shift position moving the noisy region of the signal
90
copying a region to be used as a cyclic prefix

FIGURE 8

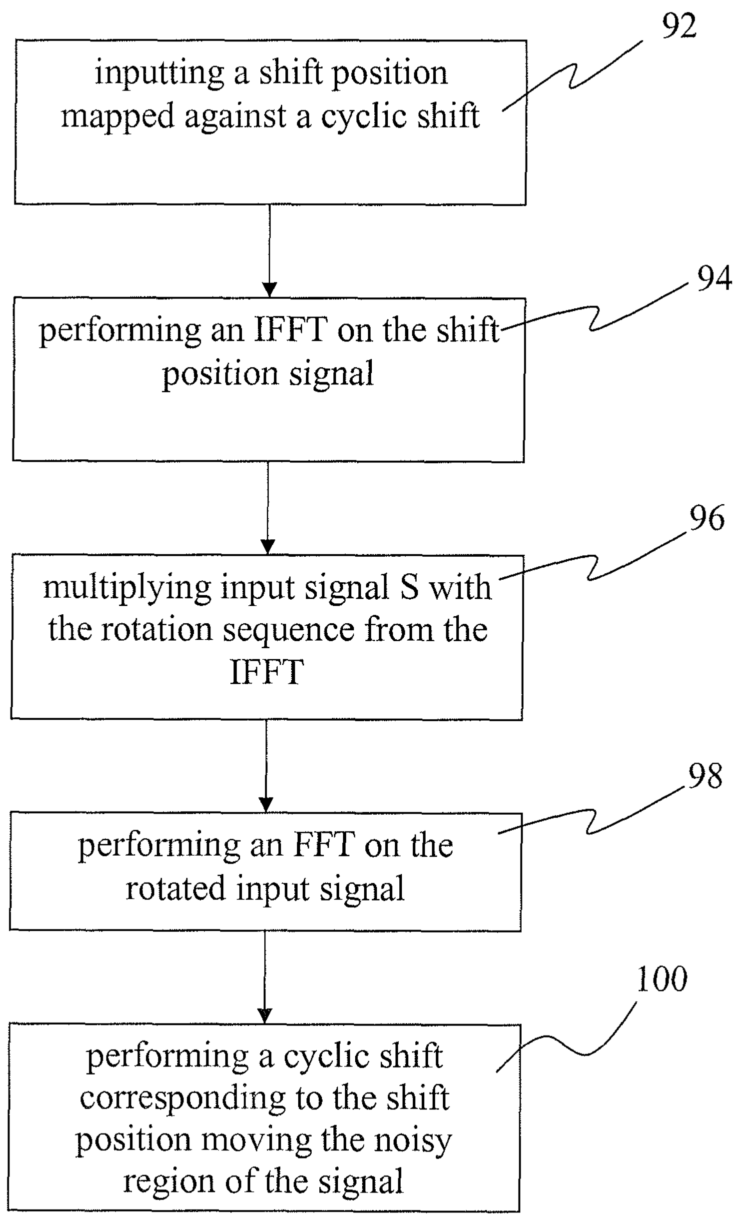
92
inputting a shift position mapped against a cyclic shift
94
performing an IFFT on the shift position signal
96
multiplying input signal S with the rotation sequence from the IFFT
98
performing an FFT on the rotated input signal
100
performing a cyclic shift corresponding to the shift position moving the noisy region of the signal

FIGURE 9

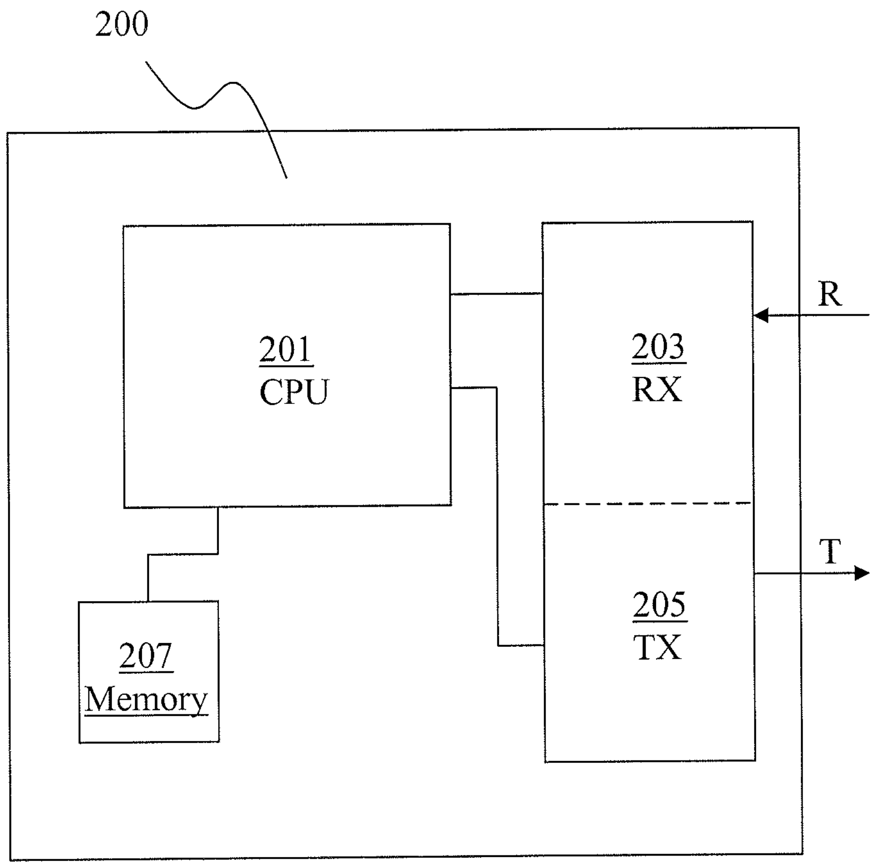

FIGURE 10

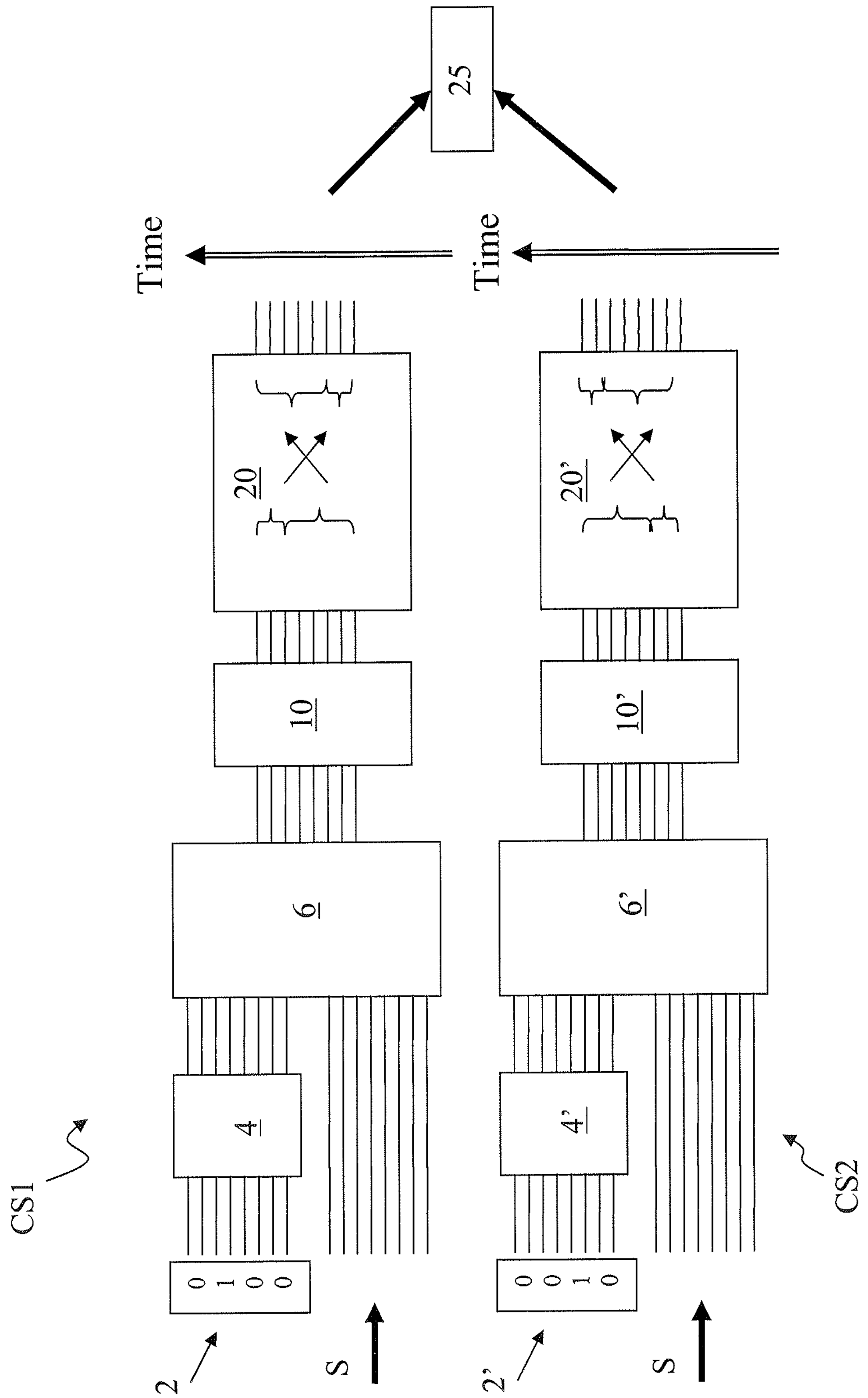

Figure 11

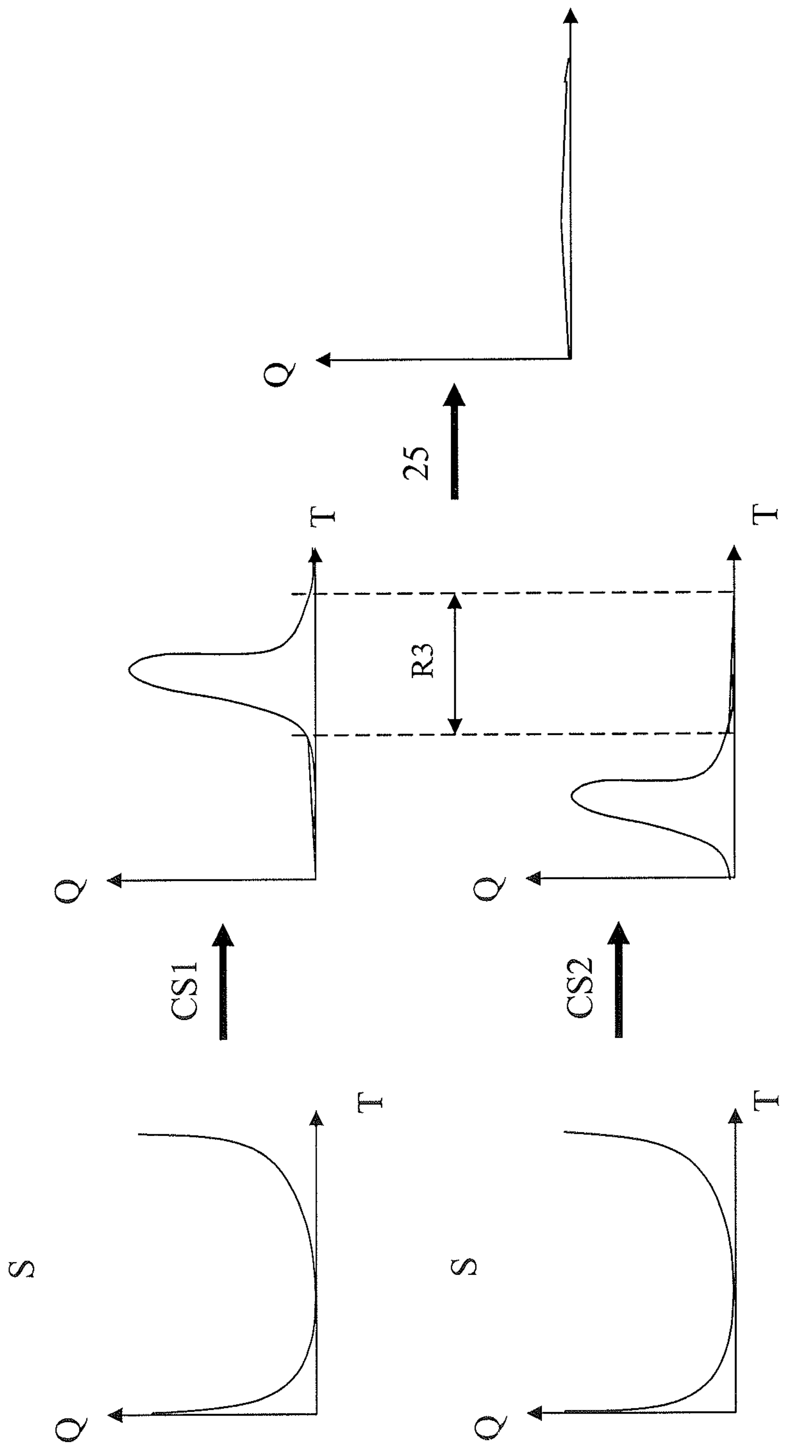

Figure 12

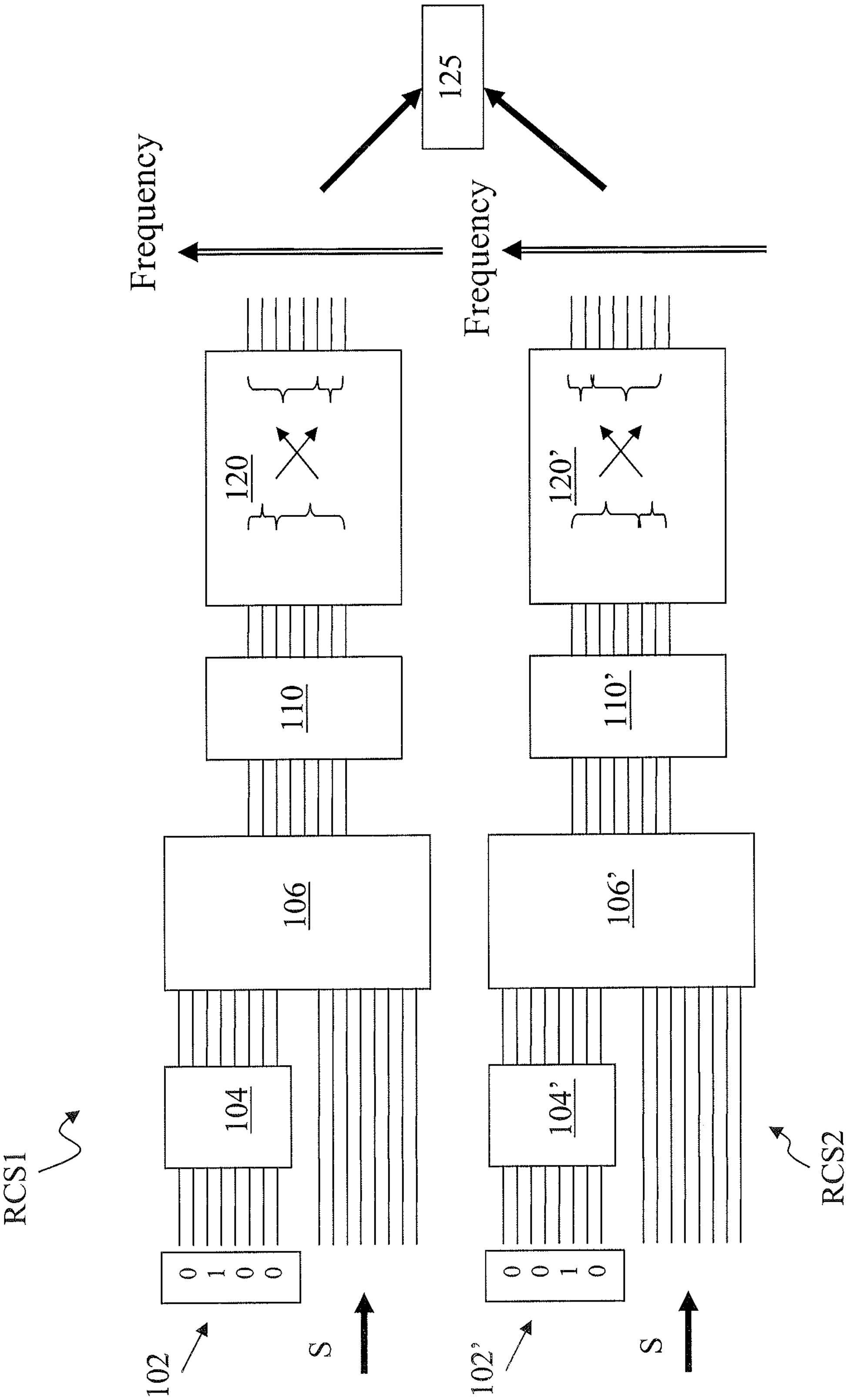
125
Frequency
Frequency
120
120'
110
110'
106
106'
104
104'
RCS1
RCS2
102
102'
0 1 0 0
0 0 1 0
S
S

Figure 13

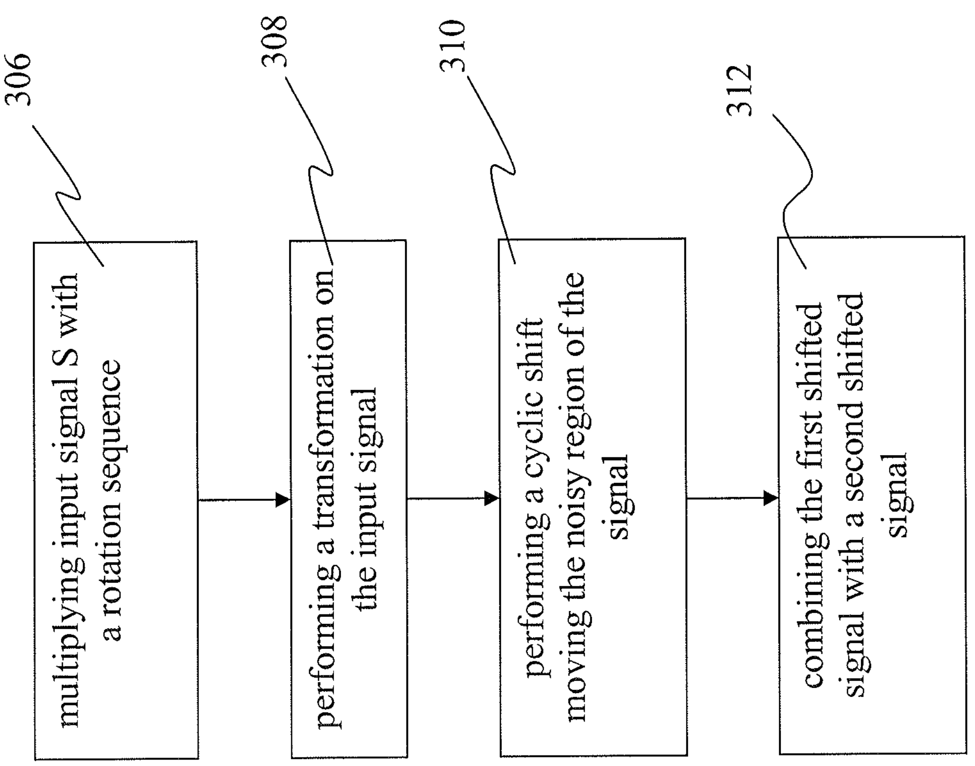
306
multiplying input signal S with a rotation sequence
308
performing a transformation on the input signal
310
performing a cyclic shift moving the noisy region of the signal
312
combining the first shifted signal with a second shifted signal

Figure 14

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- US 2005243938 A1 **[0010]**